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Model Independent Calibration and Uncertainty Analysis Toolbox (MICUT), Alpha Version One

Description

Model Independent Calibration and Uncertainty Analysis Toolbox (MICUT) is a toolbox of methods being developed to support model independent calibration and predictive uncertainty analysis. An independent implementation of the Levenberg-Marquardt (LM) method of computer-based parameter estimation has been developed from the ground up. It accommodates a model independent and input control file protocol now widely used in the environmental modeling community. MICUT software development efforts to date include:

- Robust and flexible implementations of LM and a secant (i.e., a more efficient) version of LM (SLM) (Skahill and Baggett 2006; Skahill et al. 2007).
- Robust implementations of the following stochastic global optimization methods which use the above noted LM and SLM implementations for local search (Skahill and Doherty 2006; Skahill et al. 2007):

  a. Multistart
  b. Trajectory repulsion
  c. Multilevel single linkage

An implementation supporting generalized Tikhonov regularization, which has been demonstrated to be effective in highly parameterized modeling contexts (Doherty and Skahill 2006).

Benefits

The MICUT software supports model independent calibration efforts for parsimonious and highly parameterized model settings, and it reports estimates of parameter uncertainty, correlation, and (in)sensitivity as a by-product of its use both during and after the parameter estimation process. Skahill (2006) clearly demonstrated how some of the above mentioned capabilities of MICUT could be used to improve upon the existing automatic calibration capabilities within the widely used Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS). For example, in contrast to existing HEC-HMS automated parameter estimation capabilities, methods currently in MICUT support global optimization (modelers who use automatic parameter estimation software have the right to expect that estimated parameter sets result in the best possible fit between model outputs and field measurements, with due account taken of parameter believability) and the ability to simultaneously calibrate multiple subwatershed systems represented within a HEC-HMS model (i.e., rather than calibrating multiple adjacent gauged subwatersheds independently of each other; calibrating each model individually, with, for example, possibly due recognition of the desirability of inter-subwatershed parameter similarity). In addition, using three distinct model structures, Skahill et al. (2007) demonstrated the

potential efficiency gains of using MICUT for environmental model calibration. Moreover, future uncertainty analysis functionalities soon to be included within MICUT could be used, among others, to support potentially more cost-effective design and optimal utilization of project resources prior to a (an expensive) formal model calibration process.

Status

Planned research and development efforts for MICUT include implementing function approximation methods to support efficient local and global optimization and quantification of model predictive uncertainty, and the modification of its source code to allow for the use of multiple processors. Also with respect to model calibration efficiency, the results presented in Skahill et al. (2007) suggest exploring the development of additional model calibration methods that blend multiple optimization algorithms, particularly for the calibration of computationally expensive model structures. Integration of MICUT capabilities with HEC-HMS is also planned.

Available Documentation

Skahill, B.E., J.S. Baggett, S. Frankenstein, C.W. Downer. 2007. More Efficient Levenberg-Marquardt Method Based Model Independent Calibration. *Environmental Modelling & Software* (in preparation).

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Skahill, B.E. 2006. *Potential improvements for HEC-HMS automated parameter estimation*. ERDC/CHL TR-06-13. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

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Doherty, J. and B.E. Skahill. 2006. An Advanced Regularization Methodology for Use in Watershed Model Calibration. *Journal of Hydrology*, 327:564– 577.

Point of Contact

Brian Skahill, U.S. Army Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, MS 39180, (601) 634-3441, Email: Brian.E.Skahill@usace.army.mil.

Partners

University of Wisconsin.